

The CSIRO *netCDF* archive of the World Ocean Atlas 2001

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1 Abstract

This document lists the files that make up the CSIRO *netCDF* archive of the World Ocean Atlas 2001. This *netCDF* archive derives from the *ASCII* format World Ocean Atlas 2001 available freely over the Internet and has the major advantage of being able to be imported into most plotting and analysis tools, or numerical models, that can read *netCDF* files. The files within contain temporal and spatial representation of *in-situ* temperature, salinity, oxygen, dissolved inorganic nutrients and plankton biomass.

2 Background

The purpose of this data archive is to supply the CSIRO and broader scientific community with a machine transparent, portable and self-describing format of the World Ocean Atlas 2001 (Conkright et al. 2002). This Atlas is referred to by the National Oceanographic Data Center (NODC - <http://www.nodc.noaa.gov>) with the identifier WOA01. NODC offers the WOA01 in *ASCII* format that is highly portable but not generally compact, self-describing or very efficient for processing and visualising. The *ASCII* or *netCDF* version of the WOA01 can be used to initialise numerical models, verify numerical model performance, or for general oceanographic and meteorological analysis.

Both gridded 5° by 5° and 1° by 1° longitude/latitude *ASCII* datasets are available from the NODC. Only the 1° by 1° dataset was converted into *netCDF* format, as a coarser horizontal version (eg. 5° by 5°) can be readily generated from the finer horizontal version through standard *netCDF* tools such as FERRET, NCO or NAP¹.

The standard levels for the analysed fields are 0, 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2500, 3000, 3500, 4000, 4500, 5000 and 5500 metres. The tables in section 3 list the depths for which a particular variable is valid.

¹FERRET, NCO and NAP are freely available over the Internet

3 *netCDF* files

To locate the *netCDF* files described in this report, you will need access to the HPCCC machine (owned and operated by CSIRO) “cherax”. The directory where the data are found is called “`~csmac/ocean/data/woa`” and will be referred to here as “WOA_ROOT”. Section 9 (Appendix 2) lists several utilities that were essential in creating the data archive describe here.

There are two time-invariant files in this data set, used to determine land-sea (`landsea.nc`) and basin locations (`basin.nc`). They are found in “WOA_ROOT/other”.

`landsea.nc`: the land-sea mask gives the depth of each water column at each longitude/latitude point on the earth’s surface. “Dry” (land) grid-cells are given by the *missing_value* attribute in the *netCDF* file. “Wet” (sea) grid-cells range in value between 1 and 40. The extra levels beyond the thirty-three that were listed in section 2 are 6000, 6500, 7000, 7500, 8000, 8500 and 9000 metres.

`basin.nc`: the earth’s ocean basins are labelled with a number in the range between 1 and 58. Please refer to the WOA01 document for further information.

Each of the names given in the following tables is a *netCDF* file that have the suffix “.nc”. The symbol † in the depths column represents a depth integrated quantity. Any locations in the table with a “-” indicate that there is no valid entry, and hence no data available for that particular variable and analysis product. The naming convention for the *netCDF* files and the variable names within them follow the system described in the WOA01 documentation. However, as monthly and seasonal data are kept in a single file (rather than 12 and 4 seperate files, respectively, in the original *ASCII* data set) the file names have been slightly altered as described below:

[v][tp][ft][g]/xx/.nc

where:

[v] = variable:

t	=	Temperature
s	=	Salinity
o	=	Dissolved oxygen
a	=	Apparent oxygen utilization
x	=	Percentage oxygen saturation
p	=	Phosphate
n	=	Nitrate
i	=	Silicate
c	=	Chlorophyll
z	=	Zooplankton biomass

[tp] = time period:

00	=	Annual data
0112	=	Monthly data
1316	=	Seasonal data

where the twelve months are defined as January, February, March, April, May, June, July, August, September, October, November and December respectively. The four seasons are defined based on the Northern Hemisphere as winter (January-March), spring (April-June), summer (July-September) and autumn (October-December) respectively.

[ft] = file type:

an	=	Analysed
ma	=	Difference fields
dd	=	Number of observations
sd	=	Standard deviation
se	=	Standard error of mean
mn	=	Means
oa	=	Interpolation error fields
gp	=	Grid point fields

[g] = grid size:

1	=	one-degree square file
---	---	------------------------

/xx] = plankton type identifier:

dv	=	Zooplankton displacement volume
sv	=	Zooplankton settled volume
wm	=	Zooplankton wet mass
dm	=	Zooplankton dry mass
am	=	Zooplankton ash-free dry mass
cc	=	Zooplankton carbon content

For example:

t00an1.nc	=	analysed annual <i>in-situ</i> temperature
c1316dd1.nc	=	number of seasonal chlorophyll observations
o0112an1.nc	=	analysed monthly oxygen

A primary aim of this data archive initiative was to be able to plot and analyse the World Ocean Atlas using the software FERRET (see Acknowledgements). If users of the CSIRO netCDF archive of the World Ocean Atlas 2001 require modifications to the netCDF conventions and to suit their choice of netCDF software (see Disclaimer), please contact the author of this report.

3.1 Annual data

Variable	Raw units	Analysed	Unanalysed mean of data	Difference fields	Grid point fields
Temperature	°C	t00an1	t00mn1	t00ma1	t00gp1
Salinity	PPS	s00an1	s00mn1	s00ma1	s00gp1
Dissolved oxygen	ml l ⁻¹	o00an1	o00mn1	o00ma1	o00gp1
Apparent oxygen utilization	ml l ⁻¹	a00an1	a00mn1	a00ma1	a00gp1
Percentage oxygen saturation	%	x00an1	x00mn1	x00ma1	x00gp1
Phosphate	µM	p00an1	p00mn1	p00ma1	p00gp1
Nitrate	µM	n00an1	n00mn1	n00ma1	n00gp1
Silicate	µM	s00an1	s00mn1	s00ma1	s00gp1
Chlorophyll	mg m ⁻³	c00an1	-	-	c00gp1
Zooplankton displacement volume	ml m ⁻³	dv00an1	z00mn1dv	-	-
Zooplankton settled volume	ml m ⁻³	sv00an1	z00mn1sv	-	-
Zooplankton wet mass	mg m ⁻³	wm00an1	z00mn1wm	-	-
Zooplankton dry mass	mg m ⁻³	dm00an1	z00mn1dm	-	-
Zooplankton ash-free dry mass	mg m ⁻³	am00an1	z00mn1am	-	-
Zooplankton carbon content	mg - C m ⁻³	cc00an1	z00mn1cc	-	-
Variable	Number of observations	Standard deviation	Standard error of mean	Interpolation error fields	Depths (metres)
Temperature	t00dd1	t00sd1	t00se1	t00oa1	0-5500
Salinity	s00dd1	s00sd1	s00se1	s00oa1	0-5500
Dissolved oxygen	o00dd1	o00sd1	o00se1	o00oa1	0-5500
Apparent oxygen utilization	o00dd1	a00sd1	a00se1	a00oa1	0-5500
Percentage oxygen saturation	x00dd1	x00sd1	x00se1	x00oa1	0-5500
Phosphate	p00dd1	p00sd1	p00se1	p00oa1	0-5500
Nitrate	n00dd1	n00sd1	n00se1	n00oa1	0-5500
Silicate	s00dd1	s00sd1	s00se1	s00oa1	0-5500
Chlorophyll	c00dd1	c00sd1	c00se1	c00oa1	0-100 [†]
Zooplankton displacement volume	z00dd1dv	-	-	-	0-200 [†]
Zooplankton settled volume	z00dd1sv	-	-	-	0-200 [†]
Zooplankton wet mass	z00dd1wm	-	-	-	0-200 [†]
Zooplankton dry mass	z00dd1dm	-	-	-	0-200 [†]
Zooplankton ash-free dry mass	z00dd1am	-	-	-	0-200 [†]
Zooplankton carbon content	z00dd1cc	-	-	-	0-200 [†]

Table 1: Name prefix for files located in *WOA_ROOT/annual*.

3.2 Monthly data

Variable	Raw units	Analysed	Unanalysed mean of data	Difference fields	Grid point fields
Temperature	°C	t0112an1	t0112mn1	t0112ma1	t0112gp1
Salinity	PPS	s0112an1	s0112mn1	s0112ma1	s0112gp1
Dissolved oxygen	ml l ⁻¹	o0112an1	o0112mn1	o0112ma1	o0112gp1
Apparent oxygen utilization	ml l ⁻¹	a0112an1	a0112mn1	a0112ma1	a0112gp1
Percentage oxygen saturation	%	x0112an1	x0112ma1	x0112mn1	x0112gp1
Phosphate	µM	p0112an1	p0112mn1	p0112ma1	p0112gp1
Nitrate	µM	n0112an1	n0112mn1	n0112ma1	n0112gp1
Silicate	µM	i0112an1	i0112mn1	i0112ma1	i0112gp1
Variable	Number of observations	Standard deviation	Standard error of mean	Interpolation error fields	Depths (metres)
Temperature	t0112dd1	t0112sd1	t0112se1	t0112oa1	0-1500
Salinity	s0112dd1	s0112sd1	s0112se1	s0112oa1	0-1500
Dissolved oxygen	o0112dd1	o0112sd1	o0112se1	o0112oa1	0-1500
Apparent oxygen utilization	a0112dd1	a0112sd1	a0112se1	a0112oa1	0-1500
Percentage oxygen saturation	x0112dd1	x0112sd1	x0112se1	x0112oa1	0-1500
Phosphate	p0112dd1	p0112sd1	p0112se1	p0112oa1	0-500
Nitrate	n0112dd1	n0112sd1	n0112se1	n0112oa1	0-500
Silicate	i0112dd1	i0112sd1	i0112se1	i0112oa1	0-500

Table 2: Name prefix for files located in *WOA_ROOT/monthly*.

3.3 Seasonal data

Variable	Raw units	Analysed	Unanalysed mean of data	Difference fields	Grid point fields
Temperature	°C	t1316an1	t1316mn1	t1316ma1	t1316gp1
Salinity	PSS	s1316an1	s1316mn1	s1316ma1	s1316gp1
Dissolved oxygen	ml l ⁻¹	o1316an1	o1316mn1	o1316ma1	o1316gp1
Apparent oxygen utilization	ml l ⁻¹	a1316an1	a1316mn1	a1316ma1	a1316gp1
Percentage oxygen saturation	%	x1316an1	x1316mn1	x1316ma1	x1316gp1
Phosphate	µM	p1316an1	p1316mn1	p1316ma1	p1316gp1
Nitrate	µM	n1316an1	n1316mn1	n1316ma1	n1316gp1
Silicate	µM	s1316an1	s1316mn1	s1316ma1	s1316gp1
Chlorophyll	mg m ⁻³	c1316an1	c1316mn1	c1316ma1	c1316gp1
Zooplankton carbon content	mg - C m ⁻³	-	z1316mn1	z1316ma1cc	-
Variable	Number of observations	Standard deviation	Standard error of mean	Interpolation error fields	Depths (metres)
Temperature	t1316dd1	t1316sd1	t1316se1	t1316oa1	0-5500
Salinity	s1316dd1	s1316sd1	s1316se1	s1316oa1	0-5500
Dissolved oxygen	o1316dd1	o1316sd1	o1316se1	o1316oa1	0-5500
Apparent oxygen utilization	a1316dd1	a1316sd1	a1316se1	a1316oa1	0-5500
Percentage oxygen saturation	x1316dd1	x1316sd1	x1316se1	x1316oa1	0-5500
Phosphate	p1316dd1	p1316sd1	p1316se1	p1316oa1	0-500
Nitrate	n1316dd1	n1316sd1	n1316se1	n1316oa1	0-500
Silicate	s1316dd1	s1316sd1	s1316se1	s1316oa1	0-500
Chlorophyll	c1316dd1	c1316sd1	c1316se1	c1316oa1	0
Zooplankton carbon content	z1316dd1cc	-	-	-	0

Table 3: Name prefix for files located in *WOA_ROOT/seasonal*.

4 Sample figures

This section includes three plots that have been made directly from the data archive using the software FERRET. FERRET “go” journal scripts are given in section 8 (Appendix 1), and will terminate normally if running FERRET in the *WOA_ROOT* directory.

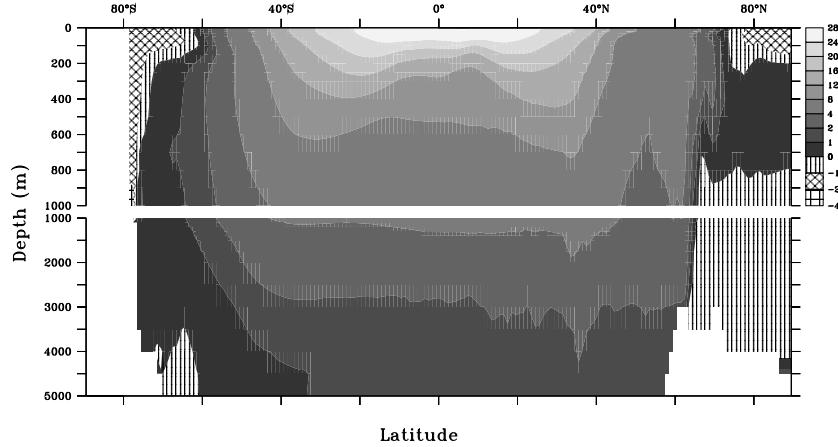


Figure 1: Meridionally averaged zonal cross-section of annual *in-situ* temperature for the world's ocean from annual temperature data file t00an1.nc ($^{\circ}\text{C}$).

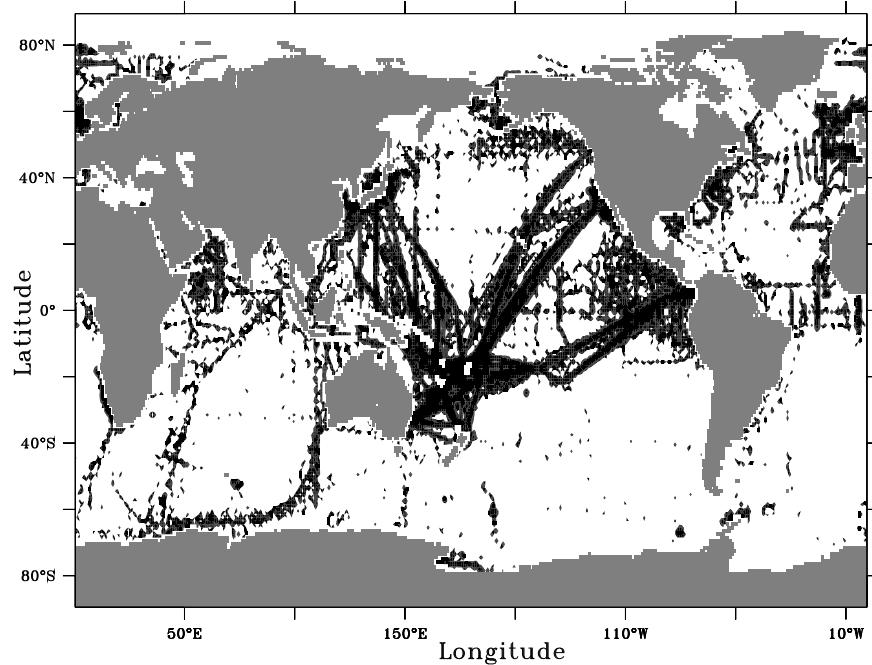


Figure 2: Location of surface chlorophyll observations from seasonal chlorophyll data file c1316dd1.nc

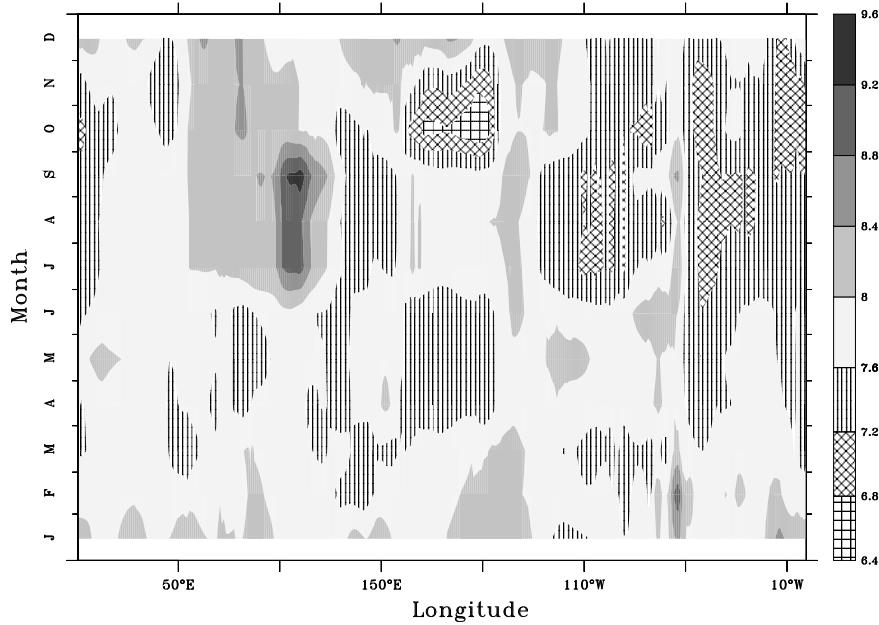


Figure 3: Annual cycle of dissolved oxygen averaged between 65°S and 90°S from monthly dissolved oxygen data file o0112an1.nc (ml l^{-1}).

5 Acknowledgments

Thanks to the NODC for making the *ASCII* files directly available through the Internet (http://www.nodc.noaa.gov/OC5/WOA01/pr_woa01.html) and the CSIRO/BMRC HPCCC (<http://www.hpc.csiro.au>) for helping to manage the archive through their massive magnetic tape/disk storage system. FERRET was used to generate the figures in this document and is available free of charge through the Internet (<http://ferret.wrc.noaa.gov/Ferret>).

6 Disclaimer

CSIRO did not generate the data for the World Ocean Atlas, and takes no credit or responsibility for it. The conversion of the World Ocean Atlas data to *netCDF* is quite straightforward, however, it is up to the users of the CSIRO World Ocean Atlas *netCDF* archive to check and reassure themselves of its numerical integrity and applicability to research applications. The CSIRO World Ocean Atlas *netCDF* archive may be modified or updated at any time without any prior warning. If you have any questions regarding this document, please contact the author, preferably by e-mail.

7 References

Conkright, M.E., R.A. Locarnini, H.E. Garcia, T.D. O'Brien, T.P. Boyer, C. Stephens and J.I. Antonov, 2002: World OCEAN ATLAS 2001: Objective Analyses, Data Statistics and Figures, CD-ROM Documentation. National Oceanographic Data Center, Silver Spring, MD, **17**, 17 pp.

8 Appendix 1: UNIX utilities

The *fortran 77* code *WOA_ROOT/src/ascii2netcdf.F* has been used to generate the annual, seasonal and monthly *netCDF* files, in conjunction with the standard *netCDF* tool “*NCGEN*”.

The directory *WOA_ROOT/bin* contains a number of essential tools for establishing the *netCDF* archive:

- | | |
|--------------|--|
| ascii2netcdf | - <i>CRAY</i> supercomputer executable for reading raw <i>ASCII</i> data and writing to preformed <i>netCDF</i> files |
| annual | - <i>UNIX KSH</i> script to process annually averaged fields |
| monthly | - <i>UNIX KSH</i> script to process monthly averaged fields |
| seasonal | - <i>UNIX KSH</i> script to process seasonal averaged fields |
| compile | - <i>UNIX KSH</i> script to create cray executable <i>ascii2netcdf</i> from <i>fortran 77</i> code <i>ascii2netcdf.F</i> |
| transfer | - <i>UNIX KSH</i> script to transfer complete set of raw <i>ASCII</i> data |

These can be executed from any machine account with very little modification.

9 Appendix 2: Example *FERRET* plotting scripts

Script for figure 1:

```

set memory/size=50
cancel data/all
cancel var/all
cancel viewport

ppl dfltfnt TR

let iprint=0
let iprint=1 !generate metacode and postscript and transfer postscript

define view/xlimits=.01,.99/ylimits=.45,.95 top
define view/xlimits=.01,.99/ylimits=.20,.70 bot

use "annual/t00an1.nc"

cancel viewport
set viewport top
let vari=t00an1[x=@ave,z=0:1000]

```

```

let var2=t00an1[x=@ave,z=1000:5000]

fill/axes=0,0,0,0/nolab/nokey/pal=greyscale var1

let ylo = ($ppl$yorg)
let ymid = ylo + ($ppl$ylen)*8/29
let yhi = ylo + ($ppl$ylen)
let xlo = ($ppl$xorg) + ($ppl$xlen) + .2
let xhi = xlo + .6

if 'iprint eq 1' then
set mode metafile:xsection.gm
endif

fill/axes=1,0,1,1/set_up/nolab/nokey/lev=(0)(1)(2)(4,28,4)/pal=greyscale var1
ppl shakey 1, 1, 0.08, 0, 4, 6, 'xlo', 'xhi', 'ymid', 'yhi'

ppl fill
fill/over/axes=1,0,1,1/set_up/nolab/key/lev=(-4)(-2)(-1)(0)/pal=black/pat=3patterns var1
ppl shakey 1, 1, 0.08, 0, 4, 6, 'xlo', 'xhi', 'ylo', 'ymid'

ppl fill/over
pattern solid

set viewport bot
fill/axes=0,1,1,1/nolab/nokey/lev=(0)(1)(2)(4,28,4)/pal=greyscale var2
fill/over/axes=0,1,1,1/nolab/nokey/lev=(-4)(-2)(-1)(0)/pal=black/pat=3patterns var2

label -105.0,2000.0,-1.0,90,.16 "Depth (m)"
label -15.0,6000.0,-1.0,0,.16 "Latitude"

if 'iprint eq 1' then
cancel mode metafile
sp Fprint -p portrait -l cps -R -o xsection.ps xsection.gm
endif

```

Script for figure 2:

```
set memory/size=50
cancel data/all
cancel var/all
cancel viewport

ppl dfltfnt TR

let iprint=0
let iprint=1 !generate metacode and postscript and transfer postscript

use "seasonal/c1316dd1.nc"

if 'iprint eq 1' then
  set mode metafile:horizontal.gm
endif

cancel viewport
fill/nolab/nokey/pal=black/lev=(1,5,1)(200,1000,200) c1316dd1[l=@sum]
go fland

label 165.0,-105.0,-1.0,0,.16 "Longitude"
label -20.0,-20.0,-1.0,90,.16 "Latitude"

if 'iprint eq 1' then
  cancel mode metafile
  sp Fprint -p portrait -l cps -R -o horizontal.ps horizontal.gm
endif
```

Script for figure 3:

```

set memory/size=50
cancel data/all
cancel var/all
cancel viewport

ppl dfltfnt TR

let iprint=0
let iprint=1 !generate metacode and postscript and transfer postscript

use "monthly/o0112an1.nc"

let var=o0112an1[y=60s:90s@ave,z=0]

fill/axes=0,0,0,0/nolab/nokey/lev=(-999)/pal=inverse_greyscale var

let ylo = ($ppl$yorg)
let ymid = ylo + ($ppl$ylen)*1.2/3.4
let yhi = ylo + ($ppl$ylen)
let xlo = ($ppl$xorg) + ($ppl$xlen) + .3
let xhi = xlo + .6

if 'iprint eq 1' then
  set mode metafile:hovmoller.gm
endif

fill/axes=1,1,1,1/set_up/nolab/nokey/lev=(7.6,9.6,.4))/pal=inverse_greyscale var
ppl shakey 1, 1, 0.08, 0, 4, 6, 'xlo', 'xhi', 'ymid', 'yhi'

ppl fill

label 165.0,-900.0,-1.0,0,.16 "Longitude"
label -25.0,3790.0,-1.0,90,.16 "Month"

fill/over/axes=1,1,1,1/set_up/nolab/key/lev=(6.4,7.6,.4)/pal=black/ \
pat=3patterns var
ppl shakey 1, 1, 0.08, 0, 4, 6, 'xlo', 'xhi', 'ylo', 'ymid'

ppl fill/over

```

```
pattern solid

if 'iprint eq 1' then
cancel mode metafile
sp Fprint -p portrait -l cps -R -o hovmoller.ps hovmoller.gm
endif
```

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